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Stabilizing new-product development processes – a prerequisite or a barrier to satisfy customer wants and needs?

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Abstract

In lean manufacturing, stabilization is viewed as the most fundamental element for achieving efficient work processes and high-quality products. This process principle is built on the fundamental assumption that the right process, under the same conditions, will reproduce itself. Consequently, the process creates reliable outputs which in turn provide successful results for the company. More recently, the concept of stabilization is also emphasized as a key enabler to realize more effective and reliable new-product development processes. This extension of the concept stems from the fact that firms are facing an ever-increasing pace of globalization, resulting in increased competition and more dynamic markets. Increasing pressure to develop and manufacture products of higher quality with more functionality, at a lower cost and in shorter time frames, brings up several important questions as to how stabilization affects innovation capability.

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1. Introduction

This paper addresses the role of stabilization in new product development. It aims to define nuances and features of stabilization according to the process of innovation, and eventually propose under which conditions stabilization may impact the corresponding efficiency and effectiveness. To investigate these relatively open questions we have conducted a study of Norwegian manufacturing firms and their particular product development practices. The study is triangularized by first aggregating the perceived relevance of stabilization from more than 50 companies based on a comprehensive survey. Then, the nuances of stabilization are narrowed down by conducting in-depth assessments at five companies represented by key personnel from management and product development. Follow-up interviews and workshops were done with one case company, providing insight into conditional features for the use of stabilization. The sum of the different perspectives provides a broad base for the overall understanding of the role of stabilization in product development.

Preliminary findings demonstrate that among the six Lean Product Development categories; customer value, knowledge, continuous improvement, standardization, stabilization, and culture - stabilization rate relatively low based on a survey answered by 55 companies and 308 individual respondents [1]. This result initiates the question as to whether the respondents are of the opinion that their company should improve their current situation or if they really mean that stabilization is irrelevant for new-product development performance. Following up this issue, we arranged several assessments, workshops and interviews, at selected companies that previously had taken part in the survey. The takeaways from these informative sessions are that stabilization depends on: 1) company strategy, 2) portfolio thinking, 3) knowledge management, 4) project planning, and 5) measuring the process and follow-up. These takeaways partly confirm that stabilization is regarded as an

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important factor for leveling the workload and utilizing the existing capacity to undertake better and more projects. However, the key elements of stabilization are quite different in product development as compared to manufacturing.

2. Literature

Stabilization in new product development is referred to in the literature of Design for Six Sigma (DFSS), Lean Product Development, Team organizing, Portfolio Management, Project Management, Design Thinking and so forth. El-Haik and Al-Aomar [2] claim that DFSS is an appropriate method not only for manufacturing processes, but also for change control in design processes and new product development in general.

More specifically, DFSS is commonly linked to quality and how product functionality meets customer needs as well as how the chosen technology will perform these functions in a robust manner over time [3]. However, the DFSS literature seems to agree that DFSS cannot relieve an organization for engineering and/or organizational excellence. It can co-exist with, and strengthen, best-practice in engineering and product development.

Recently Lean Product Development (LPD) has emerged as a holistic concept for how companies efficiently can convert their ideas, collective activities, technology and systems into a stream of products that meet the needs of customers and the strategic goals of the company. The ideas behind the concept of LPD stem from observations of Toyota and a few other Japanese companies during 1980s and 1990s outperformed their competitors regarding quality, product development time and cost, and profitability—which in turn have parallels to stabilization in manufacturing. However, the application of the lean concept in New Product Development (NPD) is not straightforward, and there are few examples outside Toyota where companies have been successful in implementing lean in NPD [4]. One of the most fundamental differences is the conception of value, which in manufacturing can be materialized by systematically eliminating wastes in the production value chain of a physical product [5]. The work-product in NPD, however, is information which has a much more complex conception of value since wastes are less obvious and the value potential is not fixed. Therefore, the inherent opportunity of searching for better solutions to solve customer problems makes NPD more value-driven than waste-driven. Morgan and Liker [4], together with Kennedy [6], Reinertsen [7], Sobek [8], all refer to LPD as enhancing stability in product development. Central stabilizing elements in this literature is design strategy (combining known technology), front-loading of projects where risks are detected and solved at an early stage, knowledge driven decisions, and resource management.

Portfolio management is another domain which is claimed to have a positive effect on product development processes. For instance, Cooper [9] and Kilen et al. [10] find that clear prioritization of ideas and projects throughout a stage-gate structure improve success rates of new products. Taking into account factors such as market opportunities, economic potential, risk along the pathway, capacity and knowledge, companies will be better off regarding stabilization in their product development processes.

The project management literature has over the years grown significantly and contributions to increased stability are project breakdown analysis, risk awareness and handling, and definitions of objectives [11]. The latter has recently been inspired by dynamic positioning and scenario management, meaning that organizations have to develop forward-looking metrics to better be prepared for the unknown [12].

Design thinking is also a method considered to combine empathy for the context of creativity with the rational to analyze and efficiently find cross-disciplinary solutions to a problem [13]. This school of thought tries to bridge the continuous dilemma of creativity versus stabilization. Although the above-mentioned literature labels things a bit differently, there are to our understanding redundancies regarding underlying factors for enhanced stabilization in new-product development processes.

2.1. Definition of stabilization

A product development system (infrastructure, organization, management and process) must provide a fundament for continuous improvements (CI), quality work and organizational performance; that is, there has to be an organizational infrastructure that facilitates strategic deployment and long term commitment to build excellence in product development. Stability can be seen in parallel to a systems perspective, which includes defining a technology and product strategy, product leadership, portfolio management, and a design reuse strategy. To secure predictable conditions in product development, resource, workload planning, and communication interfaces are also important. In addition, integration of manufacturing early in product development is a key to prevent waste, i.e. design loopbacks, resource squeezes and overruns [5]. Finally, defining core and strategic products, along with the suppliers' strategic roles in delivering value, are important for establishing a design strategy founded in lean principles.

3. Method

Three different approaches are conducted to gather data about stabilization. First, a survey was conducted to determine trends at a macro level. Thereafter, an assessment tool was developed in order to go deeper at company level. Finally, a workshop was arranged with the same case company that previously had answered both the survey and the assessment tool, gathering a mix of external experts and case company employees to discuss features of stabilization.

3.1. Survey

This study and associated research question are derived from the results from a survey conducted in Norwegian manufacturing firms between September 2011 and April 2012. The main purpose of this survey was to gain insight into the status of product development practices. These practices were categorized into the six core elements; Customer value,

Culture, Stabilization, Standardization, Continuous improvement and Knowledge – which was identified and described in a framework by Welo [14]. Each category is made up of 12 statements, which the respondents have to assess in accordance to a 5-point Likert-scale.

In total 308 respondents from 55 companies answered the survey, and criterions for selecting firms were (defined population): company size (minimum 50 employees in company), having in-house product development department, manufacturing of physical non-commodity products (not services), at least 30% value added in the manufacturing processes (revenue less purchased goods), and customer specific or engineered products.

The subjects in the sample were product development and design engineers, quality engineers, process development engineers, project managers and functional managers. The main hypothesis was that all categories had a positive influence on product development performance. Thus, each category, including product development performance, was factorized and Cronbach's alpha was calculated to vary between 0.71 and 0.88. Kline [15] and Halvorsen [16] argued that alpha-values of 0.7 or higher are acceptable, and that 0.8 or higher indicates good reliability. For further analysis of the Stabilization category each question belonging to the category is subject to comparison between the case company population and rest of the population by t-test.

3.2. Assessment tool

12 persons from the case company, with responsibilities within sales and market, product development, technology, quality, logistics and supply chain, and management, participated in a one-day workshop to assess their current and desired product development state. Data was first collected individually and thereafter analyzed by research team and presented in plenum to come up with a collective result. The assessment tool consists of the same categories as the survey, but narrowed down to 22 questions with 2-6 questions in each area. The current state and the desired future state were assessed using a guideline with a scale 1-5 for each subarea. Prior to assessing each area included in the component model, an overview of lean principles and examples were presented to the participants to provide a better understanding of the underlying factors associated with each question.

3.3. Case study

Selecting an appropriate sample is important in case research, and involves criteria like relevance to research questions, if the phenomenon to be studied may appear, and if it is feasible and ethical [17]. Against this background, a company that met the following criteria was selected for conducting the study; it has formal product development departments, part of a global value chain, it has the need to innovate and to improve its product development properties, and it had answered the aforementioned survey by more than 25 respondents, which is a minimum statistical threshold for significantly compare a company against rest of the population.

Before starting the data collection, a detailed research protocol describing data collection methods and work shop procedure was developed and pretested with academic faculty. The study method was influenced by the recent work of [18].

3.4. Case company

The case company is a high-tech company located in Norway with core competence within development and production of ammunition, rocket motors, and shoulder-launched munition systems. Advanced use of high strength metals and polymer composites, and combinations of these, makes the company a preferred supplier to leading defense system integrators around the world. The case company has more than 2,000 employees in different production sites in six countries, and its ownership is equally shared between the Norwegian government and Patria from Finland.

Product performance, quality, and reliability are main drivers in the defense and aerospace industry, providing strict guidelines for how product development projects are conducted. Moreover, it is not unusual that it takes 10-12 year from concept to a qualified and customer-approved product is ready for delivery. This time horizon calls for focus and awareness of choosing the right concept along with follow-up of cost, time, and risk by stringent management routines throughout the different (sequential) project stages. Due to the strong dependencies and interrelationships gradually evolving over time under these requirements and conditions, avoiding design iterations and re-loops is key to ensure successful outcomes. In response to this important challenge, the company has introduced a series of dependent improvement initiatives. Back in the early 1990's, they initiated an internal program named Total Quality, which was soon replaced by Agile—an improvement program that all suppliers to a major American defense actor had to comply to. Agile is a methodology commonly used in the software industry, and is elsewhere used in situations and environments for activities where scope and content are somewhat dynamic; thus, Agile is a highly relational approach to project work and product development processes.

Today, the case company uses SixSigma as their main tool to systematically improve products, processes and work routines. In total 11 people hold a black belt rank and more than 40 hold a green belt. Fact-based decisions (supported by data) are central in SixSigma. Moreover, SixSigma is a suitable approach for identifying and assessing knowledge gaps, and define actions to bridge critical gaps. Establishing practices to document project decisions and the rationale behind them through explicit knowledge is of crucial importance when projects last for many years. The number of actors escalates during the course of the project, and the team that ultimately launches the product may not at all be the same as the one that initiated it. Another reason why documentation practices grow in importance as time passes is the strategic value of continually transferring knowledge to other projects. Thus failing to provide—or delaying the generation of—correct information and valid knowledge may incur severe costs to such a heavily project-driven company.

4. Results

4.1. Survey results

Comparing all questions and categories by value the results showed that stabilization was considered significantly lower on average scores than the other categories, and the poorest p-value (0.85), a large p-value indicates weak statistical evidence, compared to product development performance. Figure 1 demonstrates by a polynomial trend line, along all questions asked in the survey, that the category stabilization is significantly lower than the other categories at statement level. It also shows that results from the case company at the stabilization category are indifferent compared to rest of the population. Mean difference are also shown in the figure, illustrating statistical significant differences by red triangle. This observation motivated us to elaborate on the topic of stabilization.

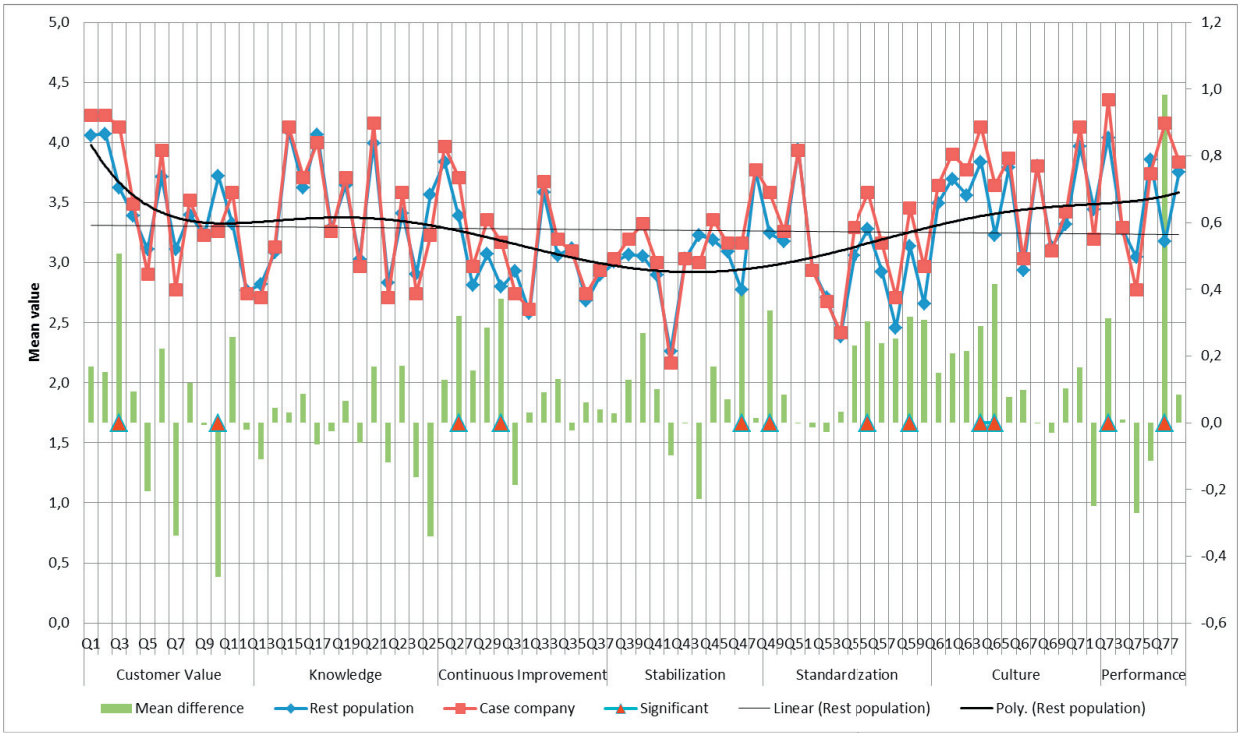

Fig. 1. Survey results for case company and the total population.

At the case company, the survey was mainly answered by employees having roles such as project managers and product and process development—in total 69 %. Among the 31 respondents more than 90 % claim to have at least six years of work experience in the company, and over 30 % report 15 years or more work experience. Regarding formal education, 84 % of the respondents have bachelor or higher graduate degree. Gender balance in the case company population is 19 % female and 81 % male.

Table 1 lists the statements/questions related to the category stabilization, where mean and standard deviation are reported for both case company and rest of the population.

A *t*-test was made to determine the significance of the deviation observed between the mean values in each question and the total sample. This test shows that only one result is significantly different from the average at $p<0.1$ level, namely, that the case company subjectively feel that their design for manufacturing efforts effectively prevent problems in industrialization and manufacturing stages.

Taking all six categories into account, the case company reports higher-than-average score in 51 out of totally 72 questions, in which nine of them are statistically significant. When isolating the stabilization category, it is therefore difficult to differentiate the case company from the rest.

4.2. Assessment results

The results show that product development at the case company is primarily driven by product performance (90 %). Averaging results for each assessment area show that the difference between the current and the desired state is in the range of 0.92 to 1.70. In all cases the desired state was significantly higher than the current, which indicates that all areas in the model are more or less relevant. As discovered in the survey this evaluation method confirms that the category stabilization, through questions related to portfolio management, resource planning, design strategy, and design for manufacturing, rates low compared to the other categories.

Table 1. Results from category stabilization.

Questions	Rest of pop. [N=275]		Case company [N=31]		
	Mean	Std. Dev.	Mean	Std. Dev.	p
We are using a holistic approach for project selection and portfolio planning with transparency to available resources?	3.004	0.940	3.032	0.861	0.865
Selection criteria for projects are based on defined metrics and primarily driven by our ability to mitigate risks while satisfying customer value?	3.065	0.884	3.194	0.692	0.356
We always prioritize projects based on their importance and everybody knows which activity to work on at any time?	3.055	1.031	3.323	0.963	0.159
Capacity shortages are proactively handled by regular resource planning, starting with functional areas cascaded down to product development teams?	2.898	0.956	3.000	0.762	0.503
Key people in product development do not have formal responsibilities in more than two projects at any time?	2.258	1.136	2.161	0.919	0.596
Planning of activities is assigned to the lowest possible organizational level to create commitment and clear responsibilities?	3.033	1.003	3.032	1.062	0.998
In our organization leaders are primarily promoted based on their (technical) competence and coaching skills?	3.229	0.935	3.000	1.136	0.294
Project management is primarily focusing on quality of deliverables and risk mitigation rather than completion of tasks and check lists?	3.185	0.881	3.355	1.033	0.393
Manufacturing (and other downstream functions) has defined authority and obligations in all project phases from concept through distribution?	3.091	1.018	3.161	0.954	0.705
In our company Design for Manufacturing (DFM) efforts effectively prevent re-loops/iterations after design freeze?	2.771	1.116	3.161	1.110	***0.076****
A few suppliers are selected as strategic partners based on their competence, capability and reliability for key components?	3.760	0.942	3.774	0.974	0.940

4.3. Work shop results

One year after the case company answered the survey the research team organized and facilitated a one-day workshop in order to discuss and propose actions to improve stabilization both at the case company and for Norwegian Manufacturing firms in general. More than 50 managers and experts from 14 companies in addition to ten employees at the case company were participating, aiming to contribute to extend the understanding of the concept of stabilization. All these companies take part in a joint national research program called CRI (Centre for Research Driven Innovation) NORMAN (Norwegian Manufacturing Future). Participants were given an overview of the company and particular projects, presentations and tours, theory about stabilization and results from the survey. Based on this information, workshop participants were split into five groups and asked to answer the following open question:

How can the case company and/or firms in general secure a more stable product development process? – prioritize until five proposals to discuss in plenum.

Table 2 shows the answers categorized by the research team into; strategy, portfolio, knowledge, project, and measure. In total 25 proposals were presented, but due to overlap in context and meaning we have condensed these down to 19 proposals. An interesting feature is that the proposals cover a broad range of categories and what could be defined as distinct stages or dependent sequences a company has to consider in order to improve its product development stability, ranging from overall company strategy to project execution and follow-up.

Table 2. Improvement proposals – stabilization.

Category / stage	**Improvement proposals regarding stabilization - from workshop at case company**
Strategy	Design strategy / Design for manufacturing / Design platform
	Standardize repetitive tasks
	Ownership of technology and products in functional organization
	Define and clarify roles between people and departments
Portfolio	Idea- and project prioritization
	Project portfolio management
	Awareness of core competence and technology
	Be prepared for peak loads
Knowledge	Knowledge transfer / Reuse of knowledge
	Fact-based decisions
	Trustworthy information in knowledge management system
	Grow talents
	Establish common language and understanding
Project	Define and quantify risk as early as possible
	Frontloading
	Project breakdown
	Communication interfaces – internal / external
	Frequent project meetings
Measure	Define objectives/KPIs for the PD-process and how to measure them

5. Discussions and Conclusion

This paper has revealed different theoretical perspectives describing implicit and explicit elements of what we will define within the topic of stabilizing product development processes. These elements are further used to develop a survey category, stabilization, which was sent and responded to by a number of Norwegian manufacturing firms. From the survey we found that stabilization scored significantly lower than other sub-categories, and it had no verified positive influence on product development performance. This realization made us ask ourselves whether stabilization is regarded as a prerequisite or a barrier to satisfy customer wants and needs. The next step was to elaborate these questions further within a case company. We chose a company that had answered the survey by more than 30 employees so we had some background material when approaching the case company. Feedback from the survey was given to a number of key-persons in the company, concluding that they agreed on their average score compared to rest of the population. Additionally they admitted that there are potentials for improvement, and that they have concrete action plans for how to improve. Thus, stabilization from their point of view is seen as important in order to improve their development and operations activities. The next step was to arrange a workshop at the case company, inviting more than 50 external managers and advisers, to identify specific and general features linked to stabilization.

The key takeaways from this informative session are that stabilization depends on; 1) the overall firm strategy and how this is derived onto design and product development, 2) how this strategy has to followed up by portfolio management to prioritize ideas and projects, 3) knowledge management, 4) project execution based on risk management, project breakdown and clear roles and responsibilities, and 5) how to measure innovation and product development processes. Seeing each element separately does not bring that much new insight, but what is interesting is the holistic perspective that emerges when pulling the pieces together. Bringing together more than 50 experienced managers, advisers and product developers is obviously extremely helpful in creating valid content in Table 2.

Overall, contributions from this paper can be used to: 1) it brings new knowledge in order to improve and complement our survey questions, 2) companies may broaden their perspective when talking about stabilization—and realizing that, depending on maturity of the organization, that stabilization sooner or later becomes a topic.

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